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Selected Contributions of India to Knowledge Systems

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A dominant theme in colonial and contemporary scholarship on India asserts the importation of sciences, math, astronomy, medicine, language and writing into India, as a result of contact with foreign powers to its West, predominantly, the works of the Greeks and Babylonians. In this paper, we highlight knowledge transmission and channels in various periods of time. We show contributions to knowledge from India from ancient periods.

***Keywords*:** Indic knowledge, Astronomy, Math, Medicine, Science, Philosophy, Greeks, Chinese, Arabs, Europeans, Portuguese, Dutch, French, British.

Introduction

Knowledge transfers between civilizations imply contact between people in various time periods. Was one civilization visited by travelers of another civilization, who carried knowledge back with them? Was the knowledge transfer expedited by a third party – such as merchants visiting both civilizations? Was there a two-way knowledge transfer, or was it one-way? Did the same knowledge rise independently in the civilizations, or did the civilizations get the common knowledge from an even earlier civilization?

Since colonial times, a narration has taken root that sciences, math, astronomy, medicine, language and writing came into India as a result of invasions by foreign powers from its West, in various periods of time. The notion that Indic culture impacted all civilizations to the East of India up to the Far East, but did not have any impact to the West of the Indus River is untenable in the presence of evidence to the contrary. Such a notion has rarely been challenged because these narrations have been continually layered, broadened in scope, and nuanced from colonial to present times. Over the years, such multi-layered narrative that borrows and builds upon each other has constructed a formidable challenge for any contrarian research.

Western societies that have traditionally seen their roots in ancient Greek, Roman, Egyptian, and Mesopotamian Biblical histories, show curious myopia in recognizing Indic content in their scientific and philosophical base, but rather, readily produce works stating the export of ideas from the West to India. After a brief initial admiration of ancient Indian works and a study of their widespread impact in the ancient world, the 1700s style colonial historiography underwent a transformation from the 1850s onward, where the dominant paradigm was to produce works that

showed recent chronology for Indian history, and also to show that Indic scholarly works borrowed from civilizations to its West. Consequently, we have narrations such as the Aryan Invasion Theory which brought chariots, iron, horses, Sanskrit and the Vedic religion to India from Central Asia. From Macedonian invasions came Greek and Babylonian ideas of math, sciences, writing and astronomy, and from Roman contact came medicine. From subsequent Muslim and European invasions came arts, culture, architecture, public governance, modernizing science and math, nationhood, and several such assertions.

While there is evidence of some importation of ideas from the West, especially in recent times, an over-arching narration of Western impact on India deserves critical attention. The subject matter is vast, covering various time-periods, geographies, and areas of knowledge – astronomy, mathematics, philosophy, medicine, technology among others, and volumes have been written on the topic [1, 2]. In this paper, we show a few instances of contributions of Indic knowledge from ancient to recent times.

Hard Constraints on Indian Narratives

Several key colonial assertions on Indian history that have acquired the status of facts in the current times constrain the present day scholarship on all aspects of Indian prehistory and history and its impact on other civilizations. These constraints include an "Aryan invasion/migration" to India from Central Asia in 1500 BCE, the dating of the Vedas from 1500 BCE onward, the time-period of Buddha in the 5th century BCE, the synchrony of "Sandrakottos" with Chandragupta Maurya, appearance of writing in the time-period of Asoka, the dating of the Upanishad period to the time of Greek contact, the appearance of mathematical astronomy and trigonometry in the beginning centuries of the current era, among other such dates [3].

The proposal of male-driven Aryan Invasion/Migration theory that seeks to bolster the hypothetical Proto-Indo-European homeland in Central Asia, using Y-chromosomal and genome-wide data (see for example [4]), encounters criticism that genetics is no indicator of migration of language and culture. Works using mtDNA robustly indicate the presence of homo sapiens in India from at least 75,000 years ago [5], and no presence of Central Asian ancestry in the Ancestral North Indian genetic pool for at least the past 12,500 years [6]. Recent archeological finds in the country reveal great antiquity of advanced human settlements and civilization in various parts of the country [7, 8]. Evidence from disciplines such as archeo-astronomy and paleo-climatology shows great antiquity of the Indian people, and offers no support for an Aryan Invasion or Aryan Migration to India. Our methodology therefore is to choose not to be fettered by the aforementioned constraints, and pursue an evidence based analysis of the various data points, and present evidence for knowledge transfers out of India in various time periods.

Pre-Historical Period

Direct evidence for transfer of knowledge is rare to come by in very ancient periods. One can seek evidence of Indic knowledge systems in the practices of ancient cultures, which establishes at the very least, contact between the civilizations, keeping the direction of knowledge-transfer on the backburner. The Atharva Veda is the oldest work containing medical information in India. Although the Atharva Veda has been placed in the so-called iron-age period of 1200 BCE (see for example, [9]) in an instance of the constrained narrative mentioned above, there is archaeo-astronomical evidence that the work is older than 3000 BCE [10]. With climate change around 2000 BCE causing wide-spread movement of people, there is some evidence that Indic people migrated westward, identified among the Mittanis, Hittites, Elamites and Kassites [11]. In [12], the author shows how the medical systems practiced in these cultures contain echoes of Vedic and Atharva Veda medical practices. Contact between these civilizations implies shared knowledge systems. For example, Seidenberg [13] in discussing the Pythagorean Theorem suggests that Old Babylonia got it from ancient India, or both got it from an even more ancient source. Seidenberg has not taken note of the antiquity of *Satapatha Brahmana* which is aware of Pythagorean triples [14], and is dated to 3000 BCE [10, 14].

Indo-Greek Knowledge Transfers

The similarities in the ancient stories of Greece and India, and the similarities of medicine, mathematics and astronomy, leads to the conclusion that the civilizations were in contact and exchanged information. India and Greece had documented contact from at least the sixth century BCE. Specifically, during the time of Darius (525 BCE) who also controlled Gandhara and Sindh, there are records of Greeks and Indians living in Persia, ostensibly a route for knowledge transmission. Herodotus also notes an Indian contingent under Xerxes that took part in the sack of Athens in 480 BCE [15], but this is unlikely to be a route for transmission.

There are several records of Greek/Persian travelers to India. Scylax of Caryanda (in modern Turkey), was commissioned by Darius to explore India and sailed the Indus in 515 BCE [15]. In [16], the author notes that Scylax might have also navigated the Ganga and traveled elsewhere in northern India, including Sri Lanka, and is a likely source for transmission of Indic knowledge.

Perhaps the most famous Greek traveler to ancient India was Pythagoras of Samos (b. 560 BCE), who is reported to have traveled to India, Persia and Egypt [17, 18], and returned to Greece as a vegetarian, and with belief in transmigration of souls, and other ideas that show exposure to Indic thought. Pythagoras started a gurukulam style of school with ascetic disciples following strict codes, a system that was followed by Plato, Socrates and Aristotle, and in whose writings, one observes strong influence of Vedanta [18, 19].

Democritus (460 BCE -370 BCE), often referred to as the father of modern science, is reported by Cicero in *de Finibus*, and Strabos in *Book XVI* as having visited India, in addition to other places in his quest for knowledge. Democritus's works are important for the key influence they had on

later Greek scholars [20]. A comparison of ideas expressed in *Vaishesika Sutra* of Rishi Kanada [21] (conservatively dated to 600 BCE) and those expressed by Democritus show common ideas, with a Vedanta slant. In [22], a compilation of various Greek thinkers and travelers to ancient India is made. Among the travelers listed are Pyrrhon a philosopher who traveled with Alexander and imbibed Indic philosophy and was the founder of the Skeptics school of thought, and Patrokles (280 BCE) whose map of India was used by Eratosthenes.

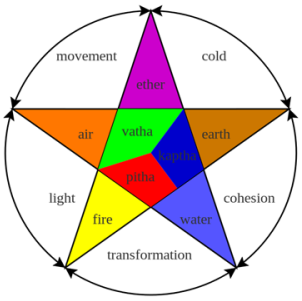
Eratosthenes was the chief librarian at Library of Alexandria. The library was setup by Ptolemy I in the 3rd Century BCE with over 40,000 works and was an important component of knowledge transmission to the West. Alexandria being at the cross-roads of travelers and traders between East and West required any berthing ship at the Mediterranean port to part with their books for copying and addition to the library, according to Galen [23]. Celebrated Greek thinkers such as Euclid, Archimedes, Eratosthenes, Herophilus, Erasistratus, Hipparchus, Aedesia, Pappus, Theon, Hypatia, and Aristarchus of Samos reportedly used the resources of this library [24]. Although more associated with Roman trade, the *Periplus of Erythrean Sea* [25] shows that from sea ports in India, ancient trader mariners hugged the coastline and thru the Red Sea, and onward by land to Mediterranean ports such as Alexandria.

The phenomenon of Precession of Equinox is referred to as Ayana Chalana in Indian works. Satpathy notes the value of Precession as noted by various ancient Siddhantas, including *Surya, Soma, Vasishta* and *Parashara Siddhantas* [26], indicating ancient knowledge of the phenomenon. Abhayankar [27] notes that Vriddha Garga in 500 BCE recorded the phenomenon as the equivalent of 1 degree in 100 years, or 36,000 years (the actual figure is 26,771 years). Hipparchus (190 BCE – 120 BCE), repeated the same figure, and allegedly used the longitudinal positions of the stars Spica and Regulus (Chitra and Magha) to measure the precession, according to Ptolemy [28], but he was also known to have got his information from Alexandria, where scholars used the Library of Alexandria as a key resource.

Pingree [29] ignores earlier Indic evidence for precession and claims that Varahamihira shows the first Indian knowledge of precession, ostensibly to bolster his thesis that "Greeks failed to communicate their astronomy correctly to Indians". Vinay Jha [30] shows much ancient evidence for knowledge of trepidation, showing that the *Vayu Purana* has astronomical data to date it to a range from "5207 BCE to 2581 BCE". Pingree further ignores prior evidence when he holds up Hipparchus as the first to mention precession, disregarding Vridda Garga, and further upholds Theon of Alexandria to first have proposed trepidation [29], whereas Theon himself admits trepidation as the idea of unnamed prior astronomers [31].

In medicine, Hippocrates (460 BCE – 370 BCE) who is regarded as the father of medicine, introduced a diagnostic model of imbalance from ideal which draws inspiration from the much earlier Ayurvedic model (Fig.1). Hippocrates was a student of Democritus who was strongly influenced by Indic knowledge. Further, Hippocrates lived at a time when areas from Gandhara to

Persian Empire were awash in Buddhist missionaries who also propagated Indic knowledge to those areas. Galen (129 CE – 201 CE) further expanded on the model introduced by Hippocrates.



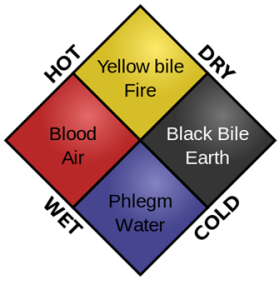


Fig.1. The Doshas of Ayurveda and the Humors of Hippocrates

Ctesias of Cnidus [32] was a physician in the Persian court from 404 BCE to 398 BCE, and wrote a book on India called *Indika*, in which he discusses at length the medicine of India [33].

Royle [34] remarks that a large part of the *materia medica* used in Greek and Roman medicine was of Indic origin. Dioscorides [35] (40 – 90 CE), a Greek physician, wrote a 5-volume *Materia Medica* with a large number of Indian herbs and recipes of drugs which was used for 16 centuries in Europe. Scholarly Nestorians from the Byzantine Empire as well as Greeks fled religious persecution to Gundeshapur in Persia (530 CE), which at the time was a center of Indian medicine and learning with large numbers of Indian physicians. The Persian emperor Anushiruwan sent his vizar to India to invite scholars and procure medical texts [36].

As examples of borrowing in mathematics, rebutting Western assertions, Krishnaswami Ayyangar [37] shows how Aryabhata's definition of pi, his rule for deriving successive sine-differences, his method of solving linear indeterminate equations, and the system of equations with present-day misnomer, "Diophantine identity", are unique works of Aryabhata, and there is no trace of these methods in Greek works, addressing the commonly quoted assertion that Aryabhata benefited from Ptolemy's works. Euclid lived in Alexandria at the time of Ptolemy I (~300 BCE), who set up the Library of Alexandria. Euclid's contributions to geometry gave a strong base to Greek mathematics. Sarasvati Amma [38] shows the extensive knowledge of geometry in the *Sulba Sutras*, conservatively dated to 800 BCE.

Indo-Arab Knowledge Transfers

The invasion of Sindh by Bin Qasim in 711 CE, opened the flood gates of Indic knowledge flowing into Arab lands and seeding their scientific thought. *Brahmasputasiddhanta* of Brahmagupta (598 CE – 668 CE) and *Khandakhadyaka* which contained works on mathematics and astronomy were transferred from India and translated into Arabic by Al-Fazari in the court of Al-Mansur (753 CE – 774 CE), popularly called *Sindhind* and *Arakand*. Al-Biruni notes that this was the first acquaintance of Arabs with scientific astronomy, as well as the Hindu numerals [39]. Manka, a Pandit in the court of Harun al-Rashid (766 CE), translated *Susrata Samhita* to Persian. This translation was used by Avicenna (~1000 CE), whose medical texts formed the foundation of European medicine from the 12th century. Abd-Allah Ibn Ali in the 9th century translated *Charaka*

Samhita to Arabic and Persian. Al-Tabari (~850 CE) wrote comparative works on Greek and Indian medicine. Al-Kindi (801-873 CE), one of the greatest Arab scientists of the period, translated several Greek and Indian works on math, medicine, astronomy, chemistry, music, and philosophy. The *Baghdad House of Wisdom* set up by Harun al-Rashid served as a massive repository for Indic works from the 8th century thru the 13th centuries, till it was destroyed in the Mongol sack of Baghdad in 1258. Al-Biruni who wrote *Kitab Tarik-Al-Hind* was a primary collator of Indic knowledge, and translated works on many subjects. Sultan Firuz ibn Tughlaq in 1365 plundered Nagarkot and acquired a library of over 1300 Sanskrit books, and translated some of them. Zain-ul-Abedin the ruler of Kashmir (1420-1470CE) had a bilateral translation department where Sanskrit works were translated to Persian and Persian works to Sanskrit. Akbar is also reported to have had Sanskrit works translated to Persian. Dara Shikoh (1615 CE), the son of Shah Jahan translated 50 Upanishads to Persian, subsequent translation of which to French gave the pre-colonial Europeans the first glimpses of Upanishads. The Arabs formed a critical link in the transmission of Indic knowledge to medieval Europe.

Indo-China-Pacific Knowledge Transfers

The Eastward transmission of knowledge to China and other Pacific nations occurred over a variety of routes. Notable among them was the Silk Route linking China and Europe. One of the oldest surviving manuscripts of Indian medicine is the Bower Manuscript [40], found in Kashgar in the 19th century. Its discovery in the Silk Route is a powerful reminder that not only goods were traded, but it also served as a conduit for spreading Indic knowledge. The Silk Route was used by innumerable Buddhist scholars, including famous Buddhist Chinese travelers such as Fa Xian (399 CE) and Huen Tseng (~630 CE), traveling from India's Northwest via Taxila and copying texts. Kumarajiva, a scholar of astronomy and Buddhism was so famous that he was captured on the orders of the Chinese emperor Fu Jian in 381 CE, and finally produced in the court of emperor Yao Xing in 401 CE, and was a primary source of transmission of Indic knowledge to China [41]. Bodhi Dharma (Shao Lin) (527 CE) and Bodhisattva Physician Nagarjuna (150 CE – 250 CE) are famous travelers from India to China. Nagarjuna who used the cataract surgery methods of Susrata is immortalized in a poem by Liu Yuxi (772-842 CE) as "*The Brahmin Priest Physician Who Bestowed Eyes*" [42]. Amoghavajra (~746 CE) is reputed to have taken 500 texts from India to China [43]. The Cholas who maintained a powerful navy are known to have spread Hindu culture in several countries in SE Asia, and had an ancient link with China dating back to at least the 2nd century BCE, according to ancient Chinese scholar Ban Gu in his book, *Book of Han* [44], and was a conduit for knowledge transfer. During the time of Raja Raja and Rajendra Chola, the countries also exchanged emissaries.

Indo-European Knowledge Transfer

We have discussed ancient knowledge transfers to Europe during the Indo-Greek transfers. An active trade between the Roman Empire and coastal India from at least 200 BCE to about 400 CE included spices, muslin, herbs, as well as transfer of medical and other knowledge. The *Periplus*

of the Erythrean Sea [25], and ancient archeological sites such as Arikamedu show evidence of such trade. The Silk Route was also indicated as a conduit for Indic knowledge to Europe. The Nestorians who fled the persecution of the Byzantine Christians and settled in Kerala as Syrian Christians also formed a conduit for knowledge transfer to Edessa and beyond [45] in various time-periods. For example, A.K. Dutta [46] notes Syrian scholar Severus Sebokht (662 CE) and a record in a Spanish Monastery in 976 CE remarking on the superiority of Indian math. The works of the Kerala School of Astronomy and Math on Calculus were transmitted by the church about 100 years prior to Newton, according to George Joseph Ghevarghese [47].

Significant injection of Indic knowledge into medieval Europe took place in Toledo and Sicily in the 12^{th} – 13^{th} centuries, where Arabic texts (several of which were either translations or secondary Arabic works based upon Sanskrit Indic works) were translated to Latin [48, 49]. These Latin translations seeded scientific thought in Europe leading to works on astronomy, mathematics, science, philosophy, and the Renaissance.

Several European travelers to India in 13^{th}-14^{th} centuries include Marco Polo (1295 CE), John of Montecorvina who was a Catholic missionary in Mylapore (1291 CE), Jordanus Catalani who was a Catholic bishop of Kollam who traveled around India in 1320s and wrote *Mirabilia*, and the missionaries Odoric of Pordenoine and James of Ireland (1318-1329 CE). Travelers of the period were either traders or seekers of knowledge or missionaries, and were conduits for knowledge transmission.

In the 15^{th} century, the prominent knowledge and trade seeking European travelers to India included Niccolo Da Conti who traveled in the Deccan, Vijayanagar, Mylapore, Quilon, Kochi, Calicut and Cambay in 1420 CE, Afanasy Niktin of Russia (1470 CE), Vasco da Dama (1498 CE), Nicolau Coelho and Bartolomeu Diaz in 1498 CE.

Vasco da Gama opened the flood-gates of colonization, with Pedro Alvares Cabral landing in India with 13 ships and 1500 men in 1500-1501 CE. Among the Portuguese scientists who landed in India in the 1500s were Pedro Nunes and Joao de Castro who was the 4^{th} viceroy to India, and formed early colonial transmission of Indic knowledge.

While the European colonizing period is characterized as a blood-soaked conquest for trade and riches, what is not mentioned is that it was also an information rush akin to a gold rush by every colonial occupier of India, where the Christian missionaries were at the lead of collecting Indic works by force, stealth, or by bribes, and translating the works and transmitting them to Europe. In addition to the Portuguese, the Dutch in Tranquebar collected many Indic works, exemplified by Bartholomaus Ziegenbalg (1705 CE). The French in Tamil Nadu collected large numbers of works and established translation facilities, exemplified by Jean-Antione Dubios (1765-1848 CE). The British collected the largest numbers of Indic works including the rarest of manuscripts (which are now in the custody of British universities and private collections).

An exhaustive list of specifics of knowledge transmissions in different subjects is beyond the scope of this conference paper. As an example of transmission of Indic medical knowledge to colonial Europe, we present a few instances. Garcia da Orta (1534 CE) in Goa, wrote *Colóquios dos simples e drogas da India*, on Ayurveda, herbs; translated to Latin by Clusius. The Dutch botanist Hendrik van Rheede (1636–1691 CE), wrote *Hortus Malabaricus,* with Ayurvedic physicians help in Malabar, Kerala. Johann Koenig, a direct pupil of Carl Linnaeus went to India as a physician in 1768 CE, was the source for Linnaeus works on botany. He also made strong reference to Garcia da Orta and to Hendrik van Rheede. Bartholomaus Ziegenbalg collected Tamil medical books in 1712 CE. Johann Ernst Grundler, 1709 CE, collected Tamil medical books and wrote *Malabarischer Medicus*. William O'Shaughnessy in 1841 CE wrote *Pharmacopoeia Indica* and *Bengal dispensatory.*

Concluding Remarks

The transmission of Indic knowledge to the rest of the world is an understated field of study, being downplayed from the colonial period onward up to the present times. The common narratives being constrained to a restrictive prehistory of India, positions India as a recipient for knowledge from outside India. In this paper, we have shown extensive contribution of Indic knowledge in every period of time in world history, and in every region of the Old World, seeding their knowledge trajectories. Owing to the vast scope of the subject, we have barely scratched the surface of this subject. Our future work will focus on critiques of works such as [50].

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